

THE VPR-300 SERIES
D-2 COMPOSITE DIGITAL VTR
FROM AMPEX.



AMPEX

PERFORMANCE, FUNCTIONALITY, CRAFTSMANSHIP.

While the VPR-300 and VPR-350 are revolutionary VTRs, the design is actually *evolutionary*. It's based on years of innovative, award-winning engineering.

The techniques used to achieve precision, high speed, gentle tape handling evolved from the transport in the Emmy Award winning VPR-3.

Important parts of the signal processing design grew out of the Zeus™ Advanced Video Processor — another Emmy winner.

And the AST™ system in the VPR-300 Series is based on further Ampex Emmy-winning engineering.

Using powerful computer aided design tools, Ampex engineers were able to develop a unique transport system that provides high speeds, gentle tape handling, and durability that's measured in years, rather than months.

The revolutionary cassette transport design features air guides and a pinchrollerless capstan hub for precise yet gentle tape handling. "Co-planar" and "helical" tape deployment modes along with a unique threading mechanism thread the tape without damaging tape distortion.

The VPR-300 accepts all three sizes of D-2 cassettes, providing play times to nearly 3½ hours. And it will automatically load and thread any of them in under four seconds.

It will recue a thirty second spot in under 1.5 seconds.

And playback lock-up time with scanner up to speed is under 20 milliseconds.

The VPR-350 accepts 32- and 94-minute cassettes. Otherwise, its performance is identical to that of the VPR-300.

If time is money in your operation, the VPR-300 Series could add to your profitability.

Full featured editing, and flexible machine interface

As an editing tool, the VPR-300 and the VPR-350 are a pleasure to work with.

It will search to a field, jog field by field and run at 60× play speed with viewable color pictures.

Full speed reverse, slow motion and still frame pictures are better than those on Type C VTRs.

And the automatic/manual *assemble, insert, read modify write* and *animate* modes are designed to ease your most complex editing tasks.

A built-in Sc/H circuit compares input and off-tape signal phasing, assuring dead-accurate edits and eliminating the time consuming process of test edits and adjustments.

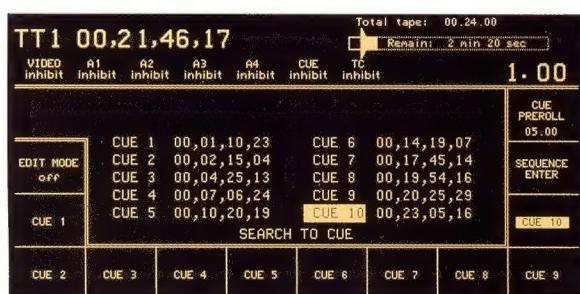
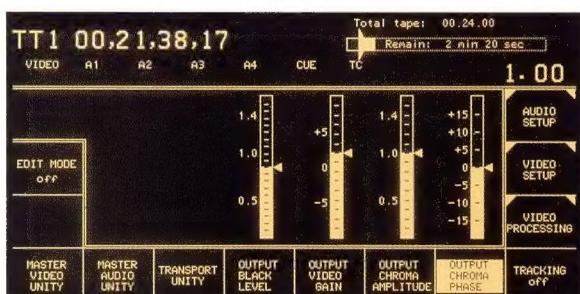
The VPR-300 Series is designed to interface with major professional editing systems, while providing machine-to-machine control without the need for external edit controllers.

The VPR-300/350 are also designed to interface with other composite analog and D-2 VTRs, as well as our ACR-225 cart machine.

AST automatic tracking and superior variable speed processing

When your work involves variable speed production techniques the AST automatic tracking system lets you vary play speed from -1 to +3 times normal.

If time compression and expansion or fit/fill are a part of your trade, the machine's unique TSO mode provides full recovery of all four digital audio channels as well as video.



Operational data, machine status, and diagnostic information are instantly available on large, interactive displays.



Using computer aided design, Ampex engineers were able to develop a unique cassette-based transport that's fast, precise, and provides gentle tape handling.

And like the Zeus processor, fully digital signal processing in the VPR-300/350 compares adjacent lines pixel-by-pixel and, through proprietary interpolation techniques, generates fully bounce- and blur-free variable speed play-back pictures.

Simple, straightforward operation

Easy-to-use softkeys and a large, clear, interactive status display make operation easy.

Displayed messages are in plain English—not cryptic codes.

Adjustable parameters are shown graphically for rapid, easy, interpretation.

And simple softkey menus give you complete operational flexibility, without complexity.

An on-board computer continually monitors the machine's operation and reports status including non-standard operating conditions.

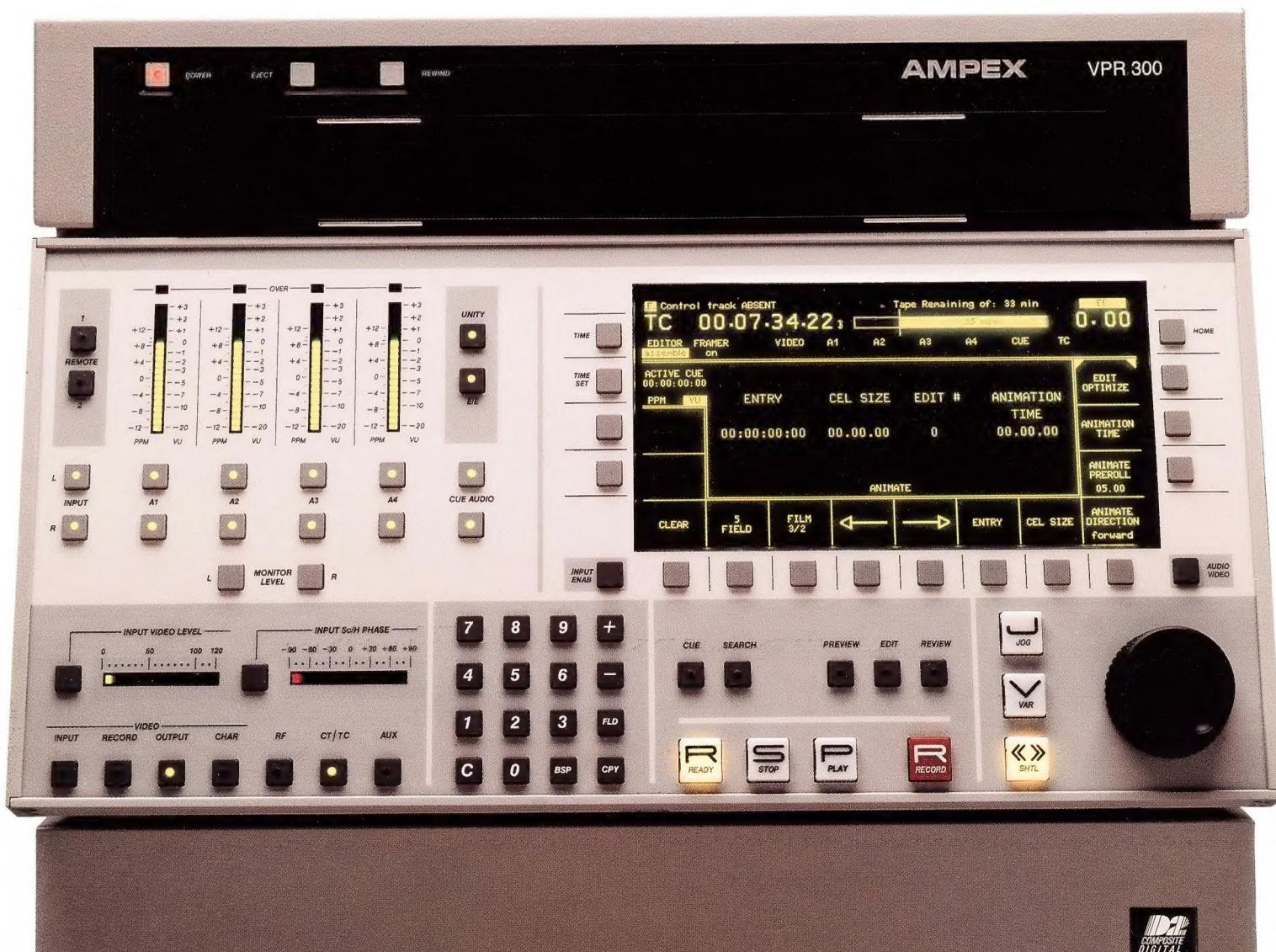
Comprehensive diagnostic systems, including powerful Signature Analysis, detect abnormal conditions and aid in their correction.

The rest of the story...

You'll find additional details in the pocket of this brochure, but to really appreciate the capabilities of the VPR-300 or VPR-350 you're going to have to see one.

Call your Ampex sales engineer today. And find out how good pictures and sound can really be.

The control panel on the VPR-300 Series is clean and functional. Controls are clearly marked and logically arranged, making operation smooth and efficient.



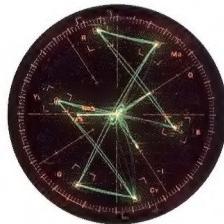
NO MATTER HOW YOU JUDGE IT, THERE'S SIMPLY NO MACHINE COMPARABLE TO THE VPR-300 SERIES.

How do you judge a VTR? By its picture quality? By its overall performance specifications?

By its operational features, speed and ease-of-use?

Or by how quickly it can pay for itself?

No matter how you measure it, there is simply no machine comparable to the VPR-300 or VPR-350.



The improvement in picture quality is instantly obvious, and sound quality is actually better than a compact disc.

Cassettes eliminate tape handling hassles. The VPR-300 supports all 3 cassette sizes—32, 94 and 208 minutes.



The Ampex developed D-2 Composite Digital format—it makes sense right now

D-2 was developed by Ampex as the logical successor to the 1" B and C formats.

Upon introduction, D-2 was quickly adopted by other major manufacturers—and for good reason.

It's *100 percent compatible* with existing composite analog equipment. All it takes to put the VPR-300 on line in today's production or broadcast facility are simple BNC and XLR cables.

Which means you can now enjoy all the benefits of digital recording without a massive investment in new equipment.

The improvement in picture and sound quality is unequivocal

On the VPR-300/350, velocity errors, impact errors and moire are nonexistent. Chroma noise is imperceptible, and other VTR color errors are eliminated entirely.

The improvement in audio is just as dramatic.

The 48 KHz sampling 1300 rate used by the VPR-300/350 is actually *higher* than the sampling rate used in mastering compact discs.

There are *four* 16-bit audio channels, each with independent editing. So stereo and multi-language recording is easy.

And when you play back sound using the digital interface, the integrity of your work is perfectly preserved.

Multigeneration performance

The number of transparent generations possible in D-2 composite digital recording is limited only by the performance of the analog signal path.

For this reason, analog circuitry in the VPR-300 Series is kept to an absolute minimum. This reduces distortion to imperceptible levels, even after as many as twenty passes through the analog circuitry.

The benefits are obvious. Post-production work, especially compositing, can be significantly faster—while tying up fewer machines.

And in broadcast, viewers will be able to see, perhaps for the first time, picture quality equal to first generation.

Inherently easier to operate

Compatibility and performance aren't the only benefits. Digital technology also makes the VPR-300 series inherently easier to operate.

Since it's a cassette machine, tape handling hassles are eliminated.

And since the digital electronics are drift-free, no time-consuming set-up is required.

Controls are simple and straight-forward, too. And a remarkable new status display makes it easy for any operator to take full advantage of the machine's powerful capabilities.

We've made no compromises

And we've cut no corners.

Feature for feature there is no video recorder in the industry comparable to the VPR-300 Series. It's an exquisitely crafted, high performance, no nonsense machine. And it's backed by the most professional service and support organization in the industry.

If you're responsible for exquisitely crafted, high quality, no nonsense video, you'll want to get your hands on one.



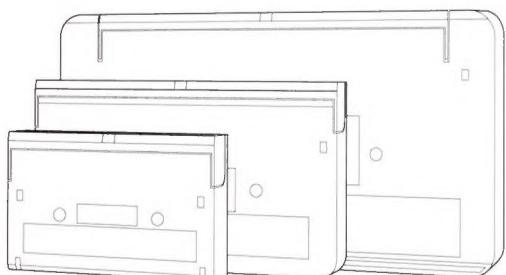
There's no need for expensive new digital hardware, or peripheral decoders/encoders. Ampex D-2 machines plug right into your existing composite analog systems with familiar BNC and XLR cables.

THE VPR-300 SERIES: THERE'S NO BETTER WAY TO GO DIGITAL

The VPR-300 and VPR-350 provide all the benefits you'd expect from a digital cassette recorder: better pictures, better sound, easier operation, higher reliability.

And it's completely compatible with existing composite video facilities.

The VPR-300 Series, there's no better way to go digital.



The VPR-300 accepts three cassette sizes with play times of up to 208 minutes, while the VPR-350 accepts the small and medium-size cassettes, providing recording over 90 minutes.

FOR INFORMATION ON AMPLEX BROADCAST VIDEO PRODUCTS CONTACT THE VIDEO SALES MANAGER NEAREST YOU.

CALIFORNIA (415) 367-2202 Redwood City	ILLINOIS (708) 590-5100 Rolling Meadows	TEXAS (214) 960-1162 Carrollton	BRAZIL (021) 541-4137 Rio de Janeiro	W. GERMANY (069) 60580 Frankfurt (Main)	MEXICO 554-9255 Mexico, D.F.	SPAIN (91) 241-0919 Madrid
(818) 365-8627 San Fernando	MARYLAND (301) 530-8800 Bethesda	WASHINGTON (206) 251-8682 Kent	CANADA (416) 821-8840 Mississauga, Ont.	HONG KONG (852) 7361866 Kowloon	NETHERLANDS 030-612921 Utrecht	SWEDEN 08/28 29 10 Sundbyberg
COLORADO (303) 279-1300 Golden	MASSACHUSETTS (617) 932-6201 Woburn	COLOMBIA 236-4659 Bogota	COLOMBIA 236-4659 Bogota	ITALY (06) 500971 Rome	NEW ZEALAND (9) 275-3085 Auckland	SWITZERLAND (037) 21.86.86 Fribourg
GEORGIA (404) 491-7112 Atlanta	NEW JERSEY (201) 825-9600 Allendale (212) 947-8633 New York	AUSTRALIA (008) 023124 North Ryde, NSW	FRANCE (01) 4270-5500 Paris	JAPAN (03) 767-4521/2/3 Tokyo	SOUTH AMERICA/ CARIBBEAN (305) 477-9836 Miami, Florida, USA	UNITED KINGDOM (0734) 875200 Reading, Berks.

VPR-300

D-2 FORMAT COMPOSITE DIGITAL RECORDER

General

The VPR-300 recorder is a D-2 format composite digital machine especially designed for the demanding VTR applications that are typical of post production. It shares the robust format, durable transport and exceptional signal system of other Ampex D-2 recorders. Like the other Ampex D-2 recorders, it can be readily integrated into existing systems without costly signal conversion devices.

Description

The VPR-300 accepts all three standard D-2 cassettes: 32-, 94- and 208-minute lengths. Thus, anything from a spot commercial to a full-length movie can be recorded, duplicated or played back on a single cassette.

A clean, functional control panel with a large interactive status display and soft keys contributes to efficient operation. Full featured editing capabilities, including an animation mode and full split editing, are standard. The rugged transport accelerates to 60 times play speed in less than one second, making the VPR-300 the fastest tape-based edit system in the industry.

Features

- High performance transport ballistics for highest tape-based editing
- Air-lubricated guides for gentle tape handling
- Accelerates to 60X play speed in less than one second
- Re-cue 30-sec spot in less than 1.5 seconds
- Full split edits from front panel
- Signal quality optimized for analog multi-gen
- Multi-gen setup mode to improve system performance
- Animation mode with 1.8 sec cycle time
- Comprehensive menus for flexible user configuration
- Full frame storage with auto freeze
- Read-Before-Write capabilities
- Slow-motion editing with no bounce/no blur
- Compensates for non-color-framed edits
- Real-time diagnostics constantly monitor machine performance
- Signature analysis speeds troubleshooting
- Individually replaceable heads



VPR-300

NTSC AND PAL SPECIFICATIONS

Specification

General

Power Requirements:

NTSC & PAL

90 to 135 Volts or 180 to 270 Volts,
48 to 66 Hz
1800 VA Nominal at 115 or 230 Volts,
Approx. 1200 Watts

Operating Environment

Temperature

Humidity

Size

Table Top

5°C-40°C

10%-90% noncondensing

597mm H × 482mm W × 705mm D
23½" H × 19" W × 27¾" D

578mm H × 432mm W × 705mm D
22¾" H × 17" × 27¾" D

114 kg (250 lbs)

Weight

Recording Format

Tape Speed

Writing Speed

Record Time

D-2 Composite Digital

131.7mm/sec

30.428m/sec

32 min. small cassette

94 min. medium cassette

208 min. large cassette

D-2 Series S, M, and L

Class 1500 tape

Ampex 319 or equivalent

Transport Characteristics

Shuttle Speed

± 7.9m/sec (60x Play)

Acceleration (maximum)

7.9m/sec² S&M

3.0m/sec² L

Fast Forward/

34 sec for 32 min.—S cassette

Rewind Speed

96 sec for 94 min.—M cassette

214 sec for 208 min.—L cassette

Servo Lock Times

20 millisec from Ready On

Color Frame P/B

1 sec from Ready Off

Tape Timer Accuracy

± 1 Frame (with continuous CTL)

± 0 Frame

Video

4 × FSc

Sampling Frequency

8 bits

Quantization

Miller²

Channel Coding

5.5 MHz ± 0.2 dB (NTSC)

Bandwidth

6.0 MHz ± 0.2 dB (PAL)

6.0 MHz — 1 dB (NTSC)

6.5 MHz — 1 dB (PAL)

S/N

≥ 54 dB (luminance)

D.G.

≤ 2.0% (ramp with 40 IRE subcarrier)

D.Φ

≤ 1.0°

K Factor

≤ 1.0% (2T)

Y/C Delay

≤ 10 nsec (20T)

Y/C xtalk

≤ 1.0%, IRE

Moiré

Not applicable

Line Tilt

≤ 0.5%

Field Tilt

≤ 1.0%

Color Gen. Lock Stability

≤ 0.2°

Specification

Analog Multi-Generation

20 Generations (4.5 per CCIR Recommendation 500-3)

Digital Multi-Generation

>20 Generations

Audio

Sampling Frequency

Quantization

Frequency Response

Dynamic Range

Headroom

Distortion

Crosstalk

Operating Level

Input/Output Level Range

Wow and Flutter

Cue

Frequency Response

S/N

Distortion

Operating Level

Signal Inputs

Video: Analog

Digital

Reference

Audio: Analog

Digital

Optional

Cue

Timecode

Signal Outputs

Video: Analog

Digital

Audio: Analog

Digital

Optional

Cue

Timecode

Character Video

Waveform Monitor

Picture Monitor

Headphones

Audio Monitor

Remotes

RS-422

RS-232

GPI

NTSC & PAL

Digital Multi-Generation

20 Generations (4.5 per CCIR Recommendation 500-3)

Audio

48 kHz (synchronized to video)

16 bits

20 Hz — 20 kHz ± 0.5 dB

≥ 90 dB at 1 kHz (ANSI "A" weighted, pre-emphasis ON)

20 dB

≤ 0.05% 20 Hz to 20 kHz

(at operating level, pre-emphasis ON)

— 80 dB (at 1 kHz)

— 8 dBm to + 8 dBm

(1 dB increments)

— ∞ to + 28 dB

Not applicable

300 Hz — 10 kHz + 2/- 3 dB

≥ 40 dB, 500 Hz — 10 kHz

≤ 1.0% (1 kHz @ operating level)

— 8 dBm to + 8.0 dBm

(1 dB increments)

0.5 V to 2.0 V p-p (75 Ω BNC)

D-2 Parallel Interface

Composite (Video or Black Burst)

(High impedance bridging, BNC)

Max. + 28 dBm (50k Ω)

D-2 Parallel Interface

AES/EBU format

Max. + 28 dBm (50k Ω)

2.4 V ± 1.4 V p-p (nominal) (10k Ω)

2 each @ 1.0 Volt p-p (75 Ω BNC)

D-2 Parallel Interface

Max. + 28 dBm Balanced

+ 22 dBm, Unbalanced (<30 Ω)

D-2 Parallel Interface

AES/EBU format

Max. + 14 dBm Balanced,

+ 8 dBm Unbalanced (<50 Ω)

2.4 Volt p-p (<300 Ω)

1.0 Volt p-p (75 Ω BNC)

1.0 Volt p-p (75 Ω BNC)

1.0 Volt p-p (75 Ω BNC)

300 milliwatt (150 Ω)

— 16 dBμ (100 Ω source)

2 each, 9 pin D, Serial

2 each, 25 pin D, Serial

1 each, 25 pin D, Parallel

Specifications subject to change without notice or obligation.

VPR-300

TRANSPORT

The production version of the Ampex D-2 tape transport is the result of over five years of development. Although it is "new" to end users, it is actually the sixth iteration of the original concept. Even before deciding on this concept, numerous alternatives were evaluated and discarded—some after extensive prototyping and testing. Our aim was to design a truly professional tape deck, capable of the demanding service expected of our previous reel-to-reel designs. In order to meet reliability goals of the VPR-300 and ACR-225, the loading mechanism had to be simple and robust; tape handling had to be precise in order to accommodate the thin tapes selected for both of the 19mm digital formats. The resulting transport was awarded U.S. Patent No. 4,652,946, covering many of the features described. This brief overview does not describe the features of the scanner assembly.

The Three Cassette Elevator

The studio version of the 19mm transport incorporates a unique elevator and reel drive mechanism, capable of accepting all three sizes of cassettes in the new 19mm family. Although this multi-size concept has been used in other professional VCRs, they have been limited to only two sizes, principally because of the difficulty in handling the extreme size difference.

The first challenge is the foolproof manual insertion of the small or medium cassette into the large loading cavity of the elevator. A series of spring-loaded gates aid the operator and insure proper centering of the cassette. Optical sensors not only detect the cassette size, but also double-check proper insertion.

The next challenge is the horizontal travel difference between loaded and ejected positions for the

extreme cassette sizes. The usual solution—an elevator tray which lifts and then travels horizontally outward—is impractical in this case. Instead, the Ampex elevator travels only vertically, but incorporates a six-wheel tractor drive which grasps and conveys the cassette the variable distance required to complete the insertion or extraction. A series of spring-loaded rails guide the cassette along the central groove common to all cassette sizes.

Another consideration is providing proper support for the cassette housing in the loaded position. Again, the extreme size difference prevents the simple solution of indexing the shell against fixed supports on the transport. The solution was to provide a rigid and stable platform within the elevator itself which is located precisely in its lowered position.

The turntables and their drive motors are mounted on movable carriages, supported by precision rails and linear ball bearings, and are driven to any of three operating positions by a servomotor through a gear and rack mechanism. A digital tachometer permits rapid and accurate repositioning of the carriages during the loading cycle. As the elevator platform lowers over the carriages, index pins lock them together to insure accurate location.

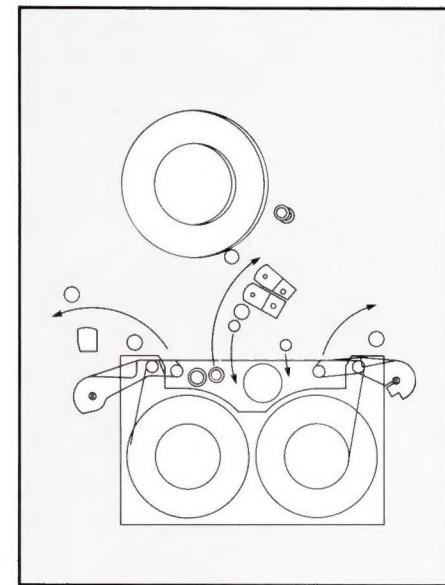
The Capstan

One fundamental choice which guided the initial transport design was the use of a direct-coupled capstan similar to high performance reel-to-reel decks such as the VPR-3. Advantages include fast accelerations and direction reversal without tape damage, plus elimination of the scuffing and stretching problems of pinch-roller systems. Both vacuum-coupled and friction-coupled hubs were considered. The coated friction hub was

chosen for its simplicity and low maintenance.

Since a direct-drive capstan must couple to the backcoated side of the tape, it must be introduced inside the tape loop extracted from the cassette. In order to avoid a "pop-up" or moving capstan and the problems of precision registration, the capstan was placed under the cassette elevator, so that it is introduced into the threading cavity as the cassette is lowered onto the turntables. Since the family of 19mm cassettes was developed concurrently with the Ampex transport, area was provided—in the otherwise wasted space between the reels—to accommodate a relatively large 1-inch (25.4mm) diameter hub, in addition to the four posts used to deploy the tape as described.

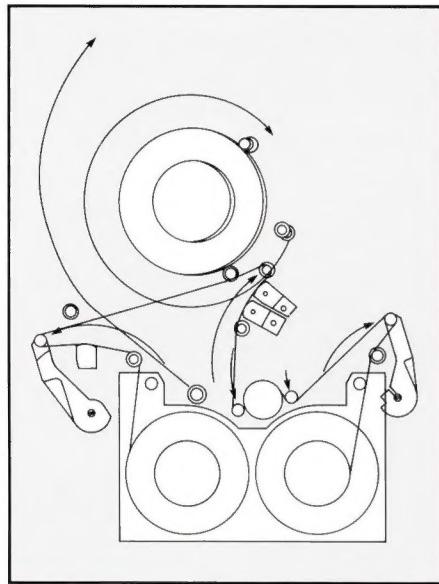
Cassette Loading



- Direct drive capstan under cassette
 - large friction hub, no pinch roller
 - tape always coupled
 - high-resolution tach
- Two high-storage tension arms
 - motors for loading plus tension control
 - permits fast accelerations, reversals

As the cassette is lowered onto the transport, several functions occur: alignment pins and supports locate the cassette shell, the reels are located and supported by the turn-table platforms, the door is lifted, brakes released, and sensor probes detect the status of the user plugs (record lockout, etc.), and the manufacturer's plugs (tape type, thickness, etc.). The first guideposts are positioned to insure there is no contact between the tape and the cassette after threading.

Coplanar Threading



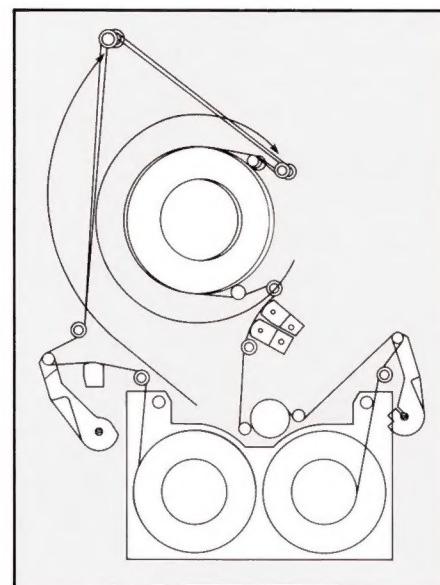
- Coplanar threading
 - threading arm
 - capstan engagement arm
- Full position, tension control
- Longitudinal heads coupled
- No contact with scanner

Extraction of the tape from the cassette is done in two distinct phases—coplanar threading, followed by helical threading. As the name implies, the first phase involves tape motion in a single plane parallel to the cassette, and the resulting tape path is similar to an audio tape deck. It begins with deployment of the two tension arms which immediately servo the reel motors to pay out tape under precise tension control. A third rotating arm completes the wrap of the longitudinal head stacks, while simultaneously swinging in a pair of guides from outside the loop to pro-

vide 180 degrees of wrap on the capstan.

Once deployed into the coplanar mode, the tape can be shuttled at high speed, erased, cued, time-code striped, and a variety of similar functions performed without contact and wear between the helical scanner and tape.

Helical Threading



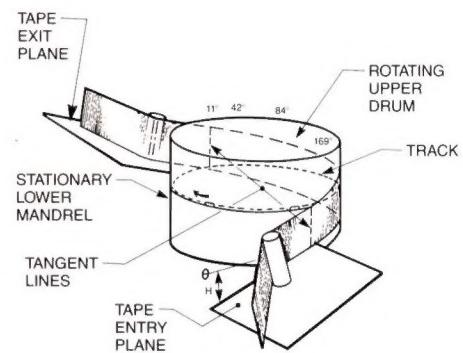
- Helical threading
- Scanner orientation
- Helix threading guide
 - computer geometry analysis
- Tilted threading guide
 - computer-generated tracks

The second threading phase advances the tape from the coplanar mode to the helically threaded mode. Because of the difference in elevation and angular orientation of the tape at scanner entry and exit points, the tape path must involve either twisted tape runs, helically wrapped posts, conical posts, or some combination of these in order to return the tape to the plane of the cassette.

Another fundamental choice which guided the Ampex transport design was to avoid helical or conical posts in favor of cylindrically wrapped guides which can be provided with edge guiding flanges or rotated to reduce friction and wear.

In most prior helical cassette recorder concepts, the tape path geometry is distorted and compromised during threading, resulting in slow thread cycles and potential tape damage. The Ampex system uses two threading guides whose motion maintains a strict "natural tape path" throughout the helical thread cycle.

Helical threading is done in one direction around the scanner, the scanner being oriented and inclined so that the tape exit plane matches the cassette and the rest of the coplanar tape path.



The first threading guide is inclined at the scanner helix angle and moves in a circular path around the scanner. However, unlike other designs with a "threading ring," this cylindrically wrapped guide also moves parallel to the scanner axis, first protruding up into the coplanar tape loop to engage the tape, then lowering the same lead as the scanner band guide and laying the tape precisely around the scanner. Correct axial motion is achieved with a double flexure assembly which supports the guide and is driven by a computer-generated cylindrical cam.

A computer analysis was used to calculate the plane of the tape leaving this threading guide during each increment of its motion and the line of intersection between this plane and the cassette tape plane. The second threading guide is moved out of the cassette along a track so its position continuously matches this calculated intersection. The guide is supported by a carriage which rolls on three track surfaces, governing the orientation and tilt angle of the guide.

to match the tape transition between these two intersection planes. The profile of the track surfaces was generated by computer-controlled machining based on the output of the tape geometry program.

The resulting tape path takes advantage of the tape runs between the supply tension arm and the scanner entry point to induce approximately 12 degrees of tape twist necessary to compensate for the helical displacement. By using these longer runs, the rate of twist is kept to approximately 1.5 degrees per inch, maintaining low tension and stress gradients in the tape.

Tape Guiding

The "weakness" of any cassette-loaded helical tape deck is the need for large amounts of tape wrap on various guideposts. Mentally compare any common deck with the original reel-to-reel audio recorders where the tape followed a simple accurate path between supply and takeup reels with a minimum of contortions. Now, typically, we see 360 degrees added to return the tape loop towards the cassette, 360 degrees added for each high-storage tension arm loop, and in some cases approximately 270 degrees added to direct tape to the high-wrap capstan. If this total wrap of over 1300 degrees were around fixed posts, the tension buildup due to friction would exceed 100 times the input tension. Clearly, non-friction guides are required. Rotating guides answer this need but introduce problems such as added inertia, runout-induced flutter, and undesirable steering of the tape. The air-film lubricated guide is a more elegant solution to the problem, having none of these faults. The Ampex transport utilizes a combination of these two types of guides with a roller-type on the tilted threading guide and air-type elsewhere.

Construction

Other features of the Ampex transport include two unique clamping mechanisms to insure precise adjustment and repeatable registration of both the coplanar and helical threading guides in the deployed position.

The cast aluminum top plate continues the Ampex approach of machined-in precision as opposed to fixture alignment of each component, thus reducing errors and simplifying assembly and field replacements. The casting is CNC machined in a unique fixture with spherical references, virtually eliminating tolerance buildups between the various mounting planes.

Since some of the transport elements are suspended from above the tape path, a rugged "bridge" casting supports four tape guides, the fixed erase head and end-of-tape photosensors, and can be quickly removed for inspection, or other access to the assemblies below.

Assembly time and serviceability are enhanced by using common mounting hardware to install each subassembly, precision dowel pins to aid location, and a minimum number of tools required to align the transport components.

Motors and Controls

The Ampex transport contains eight DC motors: scanner, capstan, reel drive (2), tension arm (2), coplanar thread gearmotor, and helical thread gearmotor. All are equipped with digital tachometers to provide position, velocity, or direction sensing to the servo system. These motors must servo to a specific position, such as the threading gearmotors, recalibrate the end positions on the first cycle after powerup, and run with an acceleration profile to cycle rapidly with crash stops.

In addition to the precise control which permits rapid tape handling, there are other bonuses gained from using digital servos linked to the system software. For

example, if there is tape in the transport when the machine is powered-up, (assuming, perhaps, a power-failure during the thread cycle), a routine determines the status of the tape path and rethreads without tape damage. This is typical of the attention given to "fail-safe" design, meaning that a fault will not result in damage to the tape or transport mechanism.

VPR-300

MULTI-GENERATION PERFORMANCE

One of the ideal features of digitized video and audio signals is the multi-generation performance that can be offered by video tape recorders that use this form of coding. The VPR-300 composite digital VTR is designed to operate in an existing composite environment and provides distortion-free signals after many generations. It is the performance of the analog signal path that eventually restricts the number of generations obtainable from any composite digital VTR. A digital component recorder operating in a digital component environment does not suffer from this potential limitation since the interface standard for the component signal is digital, hence decoding and encoding is not necessary for each generation in such equipment.

In order to ensure the VPR-300's satisfactory performance after 20 generations, the effect of each distortion was investigated and methods developed to reduce to a minimum the cumulative effects of all analog distortions.

The causes of static signal distortion in analog circuitry that subjectively impair a television picture are well known. These are imperfect frequency response, undesirable transient response caused by group delay variations, limited signal-to-noise ratio and linearity. The chrominance signal is degraded by differential gain distortion, differential phase errors and unequal luminance and chrominance delay. If the analog circuitry in the signal path is kept to an absolute minimum, even at the expense of using additional digital circuitry, and care is taken in the design, most static distortions can be reduced to imperceptible levels of impairment of a picture even after multiple passes through such circuitry.

The low pass filters used for the analog to digital and digital to analog convertors required special attention as these components ultimately determine the bandwidth and group delay of the system. It is necessary to maintain a passband ripple of 0.05 dB or less, and a group delay variation of less than 10nec with the minimum deviation occurring in the region of the subcarrier frequency, to maintain an acceptable amplitude response and minimize luminance-to-chrominance delay. Fortunately the sampling frequency chosen for the D-2 digital composite VTR is 4Fsc, which is considered super-Nyquist for the system bandwidth involved. The filter's transition band performance may be relaxed somewhat and although critical alignment is required, these filters can be realized and tuned with relative ease to achieve the desired specifications.

The sampling process of the analog to digital convertor introduces quantizing noise that, in the presence of a normal television picture, is unnoticeable. After cumulative generations this noise does degrade, but not in a linear manner. Usually the linearity of the analog to digital convertor is specified as a fraction of the least significant bit, which is unnoticeable on the first conversion. After many conversions this distortion does increase, particularly if the signal is passed through the same convertor each time, and may become noticeable after many tape generations. As nearly all convertors in use today are monolithic integrated circuits, only care in specifying, and inspection of these devices can ensure superb performance in any composite digital VTR.

The timing information for the television signal that resides in the horizontal blanking interval is not preserved for recording onto the video tape. It is redundant, for the data clock and special data synchronizing signals embedded in the data stream contain the necessary timing information. The sampling phase for the analog to digital convertor clock is defined with respect to the phase of the chroma and is calculated by measuring the color burst phase. The slightest measurement error could accumulate over many generations and seriously impair the picture. For this reason the measurement is made on the digitized signal, after analog to digital conversion, in a feedback loop that encompasses the analog to digital convertor. The black level, which is defined as a precise level in the digitized signal, is also maintained by a similar feedback loop.

The RF channel, including the head to tape interface, is the source of noise that introduces errors in the digital data. The use of a powerful error correction system corrects nearly all errors, including those caused by tape dropouts, under normal operating conditions. Severe tape dropouts that produce errors exceeding the error decoder's correction (but not detection) ability can be concealed by techniques that make use of the redundancy inherent in a television picture. Only under the most adverse operating conditions will the limitations of the RF channel and tape produce visible distortions that will degrade the signal. They do not therefore limit the number of generations that can be realized.

(continued)

Consideration must be given to other studio equipment in the recording path such as distribution amplifiers, routing and production switchers and the equalization of coaxial cable. Static analog distortions can accumulate as the signal routinely passes through such equipment with each VTR generation.

Satisfactory multi-generation performance of the VPR-300 was achieved by keeping the analog circuitry within the recorder to a minimum. Filters are available for 4Fsc sampling of video signals that can offer adequate performance without a high degree of complexity. The RF channel does not contribute to signal distortions under normal operating conditions. The remaining distortions are the linearity of the analog to digital convertor and the quantizing noise of the sampled signal, both of which are maintained to provide quality in a composite environment after many analog generations.



VPR-300

DIAGNOSTICS

The increase in both functional and electronics complexity of broadcast equipment in recent years has generated the need for increasingly sophisticated equipment diagnostic systems. Nowhere are such diagnostic capabilities more obviously necessary than in the digital video tape recorder.

An optimum recorder diagnostic capability would include provisions for both fault detection and tools to ease fault correction. Such capabilities would be in-built to the recorder, rather than expensive external equipment.

In response to these requirements, Ampex engineers have given the VPR-300 a uniquely comprehensive built-in capability providing three types of diagnostics: real time diagnostics to supply an ongoing monitor of the current "health" of the recorder; periodic diagnostics for "daily check-ups;" and fault isolation diagnostics for those occasions when a fault is detected and corrective action required.

Real Time Diagnostics

Real time diagnostics are very useful for basic system parameters such as power supply voltages, motor temperatures, capstan current, video gain and audio operating level. These parameters have well-defined norms, or limits, and the current value is easily monitored by the control system to alert the operator of any non-standard conditions. This type of diagnostics capability is offered in the VPR-3, and a significantly more comprehensive version is included in the VPR-300.

Periodic Diagnostics

Periodic diagnostics are more thorough than real time diagnostics because they can be performed "off line." The fact that the system is "off line" permits the introduction of special test signals and non-standard operating modes or conditions. These test signals can be as simple as those for a computer memory test, as is performed during power up, or the more complex pseudo random number sequence used to test the audio-video channel in conjunction with an in-built signature analyzer. Periodic diagnostic tests can be automatic, with power on, or can be called by the operator to determine the current level of system functionality. The VPR-300's in-built signature analysis capability permits comprehensive verification of the extremely high speed digital circuitry of the signal system. This level of test verifies the overall performance of the system and identifies malfunction to a given major system element.

Fault Isolation

Once a fault is detected by one of the diagnostics, or by operator observation of system performance, the fault location diagnostics are employed. These diagnostics can be used to quickly pinpoint a fault in the digital portion of the signal path. This is achieved by the automatic insertion of the special test signals, and automatic reading of the resulting signature at the prewired test nodes to determine at which board the signal path becomes corrupted. The control system boards can be tested in similar fashion by using a/d converters on the analog input and output and comparing the results to the norm.

VPR-300 diagnostics set a new standard for such capabilities in recorder systems—and indeed for broadcast equipment generally—increasing maintenance efficiency and lowering associated costs.

*For further information on the VPR-300's uniquely powerful signature analysis diagnostic capabilities, see *Diagnostics for a Composite Digital Video Tape Recorder* by William S. Herz.

ARM-300

AUDIO RACK MOUNT SYSTEM

The ARM-300 is a rack mountable high fidelity stereo audio system designed to be used with the Ampex VPR-300 D2 digital video recorder. The audio system is suitable for use with similar devices equipped with internal audio level controls.

The ARM-300 is complete with an internal power supply. The system includes a voltage selection switch at the rear panel. Input connections are made using a D subminiature connector.

Installation time is approximately 15 minutes — requiring only common hand tools. All hardware needed to install the system is included.



Specifications

Power

Switch selectable	10 Amps, 125 VAC or 5 Amps, 240 VAC
Power connection type	U.S. Standard, NEMA 5-15P
Power cord length	7.5 ft. (2.3 m)
Approvals	CSA, U.L. Listed

Audio

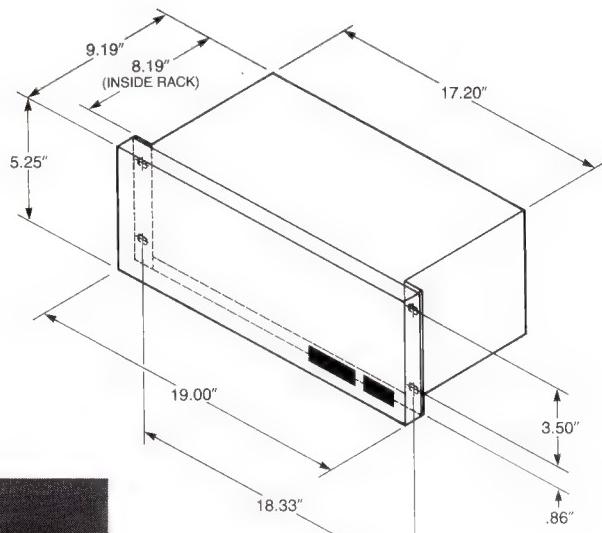
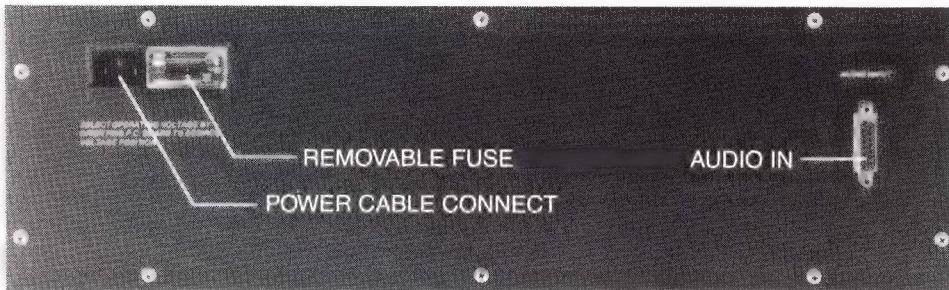
Frequency response	50-20,000 Hz
Power capacity	20 watts RMS/channel
Speaker impedance	8 ohms
Speaker specifications	Two 4" (10 cm) high-compliance woofer Two 1" (2.5 cm) dome tweeter

Hardware Provided

- 15 pin Audio Monitor Cable—13 ft. (4m)
- Power Cord—7.5 ft. (2.3 m)
- 4 Philip Head Mounting Screws

Specifications subject to change without notice or obligation.

Back Panel



Ordering Information

Catalog Number	Description	Dimensions (Height, Width, Depth)	Weight	
			Lbs	Kgs
1501660	ARM-300, Audio Rack Mount System	5.3" x 19" x 9.2" 13.3 cm x 47.5 cm x 23 cm 3 x 19" Rack Units	17.0	7.7

FOR INFORMATION ON AMPLEX BROADCAST VIDEO PRODUCTS CONTACT THE VIDEO SALES MANAGER NEAREST YOU.

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AMPEX

VPR-350 D-2 FORMAT COMPOSITE DIGITAL RECORDER

General

The VPR-350 recorder is a D-2 format composite digital machine especially designed for the demanding VTR applications that are typical of post production. It shares the robust format, durable transport and exceptional signal system of other Ampex D-2 recorders. Like the other Ampex D-2 recorders, it can be readily integrated into existing systems without costly signal conversion devices.

Description

The VPR-350 accepts two standard D-2 cassettes: 32-, and 94-minute lengths. For applications that do not require longer record/play times, the VPR-350 is a very cost-effective choice.

A clean, functional control panel with a large interactive status display and soft keys contributes to efficient operation. Full featured editing capabilities, including an animation mode and full split editing, are standard. The rugged transport accelerates to 60 times play speed in less than one second, making the VPR-350 the fastest tape-based edit system in the industry.

Features

- High performance transport ballistics for highest tape-based editing
- Air-lubricated guides for gentle tape handling
- Accelerates to 60X play speed in less than one second
- Re-cue 30-sec spot in less than 1.5 seconds
- Full split edits from front panel
- Signal quality optimized for analog multi-gen
- Multi-gen setup mode to improve system performance
- Animation mode with 1.8 sec cycle time
- Comprehensive menus for flexible user configuration
- Full frame storage with auto freeze
- Read-Before-Write capabilities
- Slow-motion editing with no bounce/no blur
- Compensates for non-color-framed edits
- Real-time diagnostics constantly monitor machine performance
- Signature analysis speeds troubleshooting
- Individually replaceable heads



VPR-350

NTSC AND PAL SPECIFICATIONS

Specification	NTSC & PAL	Specification	NTSC & PAL
<u>General</u>		<u>Analog Multi-Generation</u>	20 Generations (4.5 per CCIR Recommendation 500-3)
Power Requirements:	90 to 135 Volts or 180 to 270 Volts, 48 to 66 Hz	<u>Digital Multi-Generation</u>	>20 Generations
Operating Environment	1800 VA Nominal at 115 or 230 Volts, Approx. 1200 Watts	<u>Audio</u>	
Temperature	5°C-40°C	Sampling Frequency	48 kHz (synchronized to video)
Humidity	10%-90% noncondensing	Quantization	16 bits
Size		Frequency Response	20 Hz - 20 kHz ± 0.5 dB
Table Top	597mm H × 482mm W × 705mm D 23½" H × 19" W × 27¾" D	Dynamic Range	≥90 dB at 1 kHz (ANSI "A" weighted, pre-emphasis ON)
Rack Mount	578mm H × 432mm W × 705mm D 22¾" H × 17" × 27¾" D	Headroom	20 dB
Weight	114 kg (250 lbs)	Distortion	≤0.05% 20 Hz to 20 kHz (at operating level, pre-emphasis ON)
Recording Format	D-2 Composite Digital	Crosstalk	-80 dB (at 1 kHz)
Tape Speed	131.7mm/sec	Operating Level	-8 dBm to + 8 dBm (1 dB increments)
Writing Speed	30.428m/sec	Input/Output Level Range	-∞ to + 28 dB
Record Time	32 min. small cassette 94 min. medium cassette 208 min. large cassette	Wow and Flutter	Not applicable
Cassette Types	D-2 Series S and M	<u>Cue</u>	
Recommended Tape	Class 1500 tape Ampex 319 or equivalent	Frequency Response	300 Hz - 10 kHz + 2/- 3 dB
<u>Transport Characteristics</u>		S/N	≥40 dB, 500 Hz - 10 kHz
Shuttle Speed	± 7.9m/sec (60x Play)	Distortion	≤1.0% (1 kHz @ operating level)
Acceleration (maximum)	7.9m/sec ² S&M	Operating Level	-8 dBm to + 8.0 dBm (1 dB increments)
Fast Forward/ Rewind Speed	34 sec for 32 min. — S cassette 96 sec for 94 min. — M cassette	<u>Signal Inputs</u>	
Servo Lock Times		Video: Analog	0.5 V to 2.0 V p-p (75 Ω BNC)
Color Frame P/B	20 millsec from Ready On 1 sec from Ready Off	Digital	D-2 Parallel Interface
Tape Timer Accuracy	± 1 Frame (with continuous CTL)	Reference	Composite (Video or Black Burst) (High impedance bridging, BNC)
Edit Accuracy	± 0 Frame	Audio: Analog	Max. + 28 dBm (50k Ω)
Video		Digital	D-2 Parallel Interface
Sampling Frequency	4 × FSc	Optional	AES/EBU format
Quantization	8 bits	Cue	Max. + 28 dBm (50k Ω)
Channel Coding	Miller ²	Timecode	2.4 V ± 1.4 V p-p (nominal) (10k Ω)
Bandwidth	5.5 MHz ± 0.2 dB (NTSC) 6.0 MHz ± 0.2 dB (PAL)	<u>Signal Outputs</u>	
S/N	6.0 MHz - 1 dB (NTSC) 6.5 MHz - 1 dB (PAL)	Video: Analog	2 each @ 1.0 Volt p-p (75 Ω BNC)
D.G.	≥54 dB (luminance)	Digital	D-2 Parallel Interface
D.Φ	≤2.0% (ramp with 40 IRE subcarrier)	Audio: Analog	Max. + 28 dBm Balanced
K Factor	≤1.0°	Digital	+22 dBm, Unbalanced (<30 Ω)
Y/C Delay	≤1.0% (2T)	Optional	D-2 Parallel Interface
Y/C xtalk	≤10 nsec (20T)	Cue	AES/EBU format
Moiré	≤1.0%, IRE	Timecode	Max. + 14 dBm Balanced, + 8 dBm Unbalanced (<50 Ω)
Line Tilt	Not applicable	Character Video	2.4 Volt p-p (<300 Ω)
Field Tilt	≤0.5%	Waveform Monitor	1.0 Volt p-p (75 Ω BNC)
Color Gen. Lock Stability	≤1.0%	Picture Monitor	1.0 Volt p-p (75 Ω BNC)
	≤0.2°	Headphones	1.0 Volt p-p (75 Ω BNC)
		Audio Monitor	300 milliwatt (150 Ω)
		Remotes	-16 dBμ (100 Ω source)
		RS-422	2 each, 9 pin D, Serial
		RS-232	2 each, 25 pin D, Serial
		GPI	1 each, 25 pin D, Parallel

Specifications subject to change without notice or obligation.



CONSOLE SYSTEM FOR AMPEX D-2 VTRs

The console system is designed for use with the VPR-300 and VPR-200 series D-2 digital video recorders.

The VPR console is built for studio or production applications where system flexibility is required. The system incorporates a unique monitor bridge and docking cart for system configuration versatility.

The bridge unit accepts video and signal analyzing monitors and

comes equipped with the necessary wiring harness. The monitor angle can be adjusted for operator comfort. One rack unit of space is available under the monitor.

A stereo audio monitor system is included in the bridge and can be controlled directly from the D-2 VPR recorder.

A second version of the console system, for VPR-200 series VTRs, is

also optionally available. This version comes without a stereo audio monitoring system, since VPR-200 series VTRs are equipped with internal audio monitors.

The cart is designed to support the recorder and provide an additional ten rack units of space for equipment.

The cart and bridge may be ordered separately; refer to the order information.



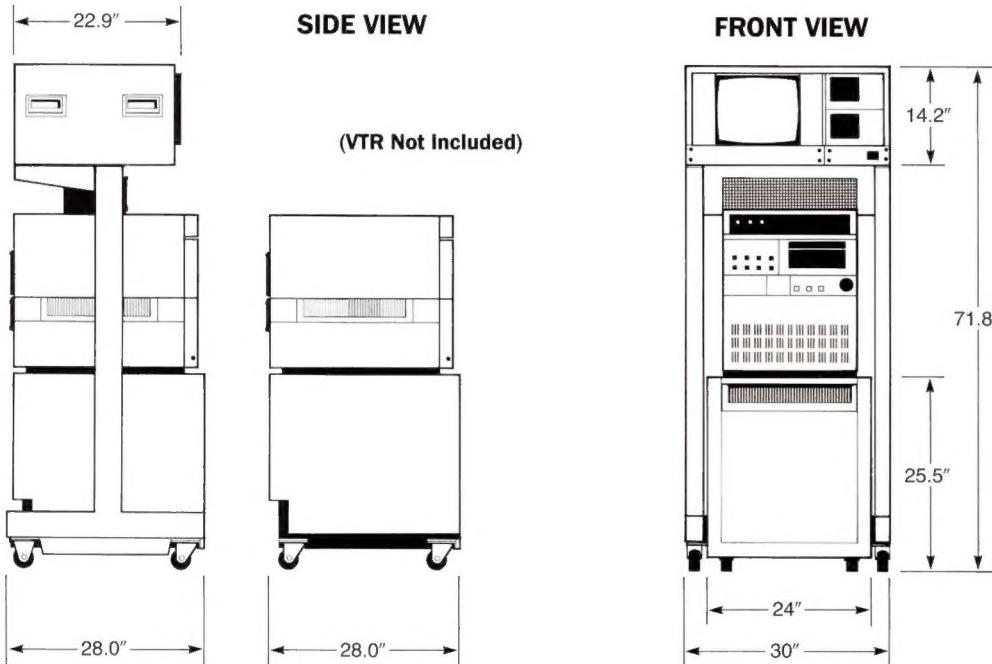
Ordering Information

Part Number	Order Code	Description	Lbs	Kgs	Dimensions (Height, Width, Depth)
1501700	I-03	Console System with ARM-300 Audio Monitoring System (Bridge and Cart)	258	117	73" x 30" x 28" 185 cm x 76 cm x 71 cm
1501710	I-04	Cart	93	42	26" x 24" x 28" 66 cm x 61 cm x 71 cm
1501740	I-05	Bridge	165	75	73" x 30" x 28"
1501620	I-06	Rolling monitor chassis Console System without ARM-300 Audio Monitoring System (Bridge and Cart)	242	110	185 cm x 76 cm x 71 cm 73" x 30" x 28" 185 cm x 76 cm x 71 cm
1501594	I-07	9" JVC Monitor Bezel (required for monitor)	8	3.6	10.5" x 15" 4.1 cm x 6 cm
1501745	I-08	9" Barco Monitor Bezel (required for monitor)	8	3.6	10.5" x 15"

Specifications subject to change without notice or obligation.

Ordering Notes:

- Audio monitoring is included with bridge (1501740).
- Specify table top version of D-2 VTR when using the console system. Reference table top kit (part number 1509895).
- Specify monitors separately.
- Order blank panel when specifying only one analyzer monitor. Reference blank panel (part number 554-229).



Key Features

- Tiltable monitor bridge
- Complete wiring assembly included with bridge
- Stereo audio monitor included with bridge (1501740) or I-03 Console System (1501700)
- Stereo audio monitor not included with I-06 console system (1501620)
- Cart handle locks in up position for easy use
- Cart docks and locks with bridge
- Cart wheels can be locked for added system stability

D2

FORMAT DESIGN AND IMPLEMENTATION

The D-2 format for digitally recording composite NTSC television signals, developed by Ampex, is the basis of the new Ampex VPR-300 studio VTR and the ACR-225 automated cassette system. This paper presents the design considerations and decisions made in arriving at the format and its implementation in commercial products.

A primary design criterion of the Ampex machines was the ability to provide many analog generations with impeccable picture quality. The D-1 component digital recorder operates in an all-digital environment and is required to produce up to twenty digital generations. The D-2 recorder is designed to operate in an analog composite environment and—although digital interface ports are provided for dubbing—the machine

must provide a similar number of generations with the signal converted from digital form to analog form and vice versa with each generation. The approach taken was to keep the analog circuitry to an absolute minimum, and use the highest quality analog to digital converters that are available.

Among the topics presented are the criteria for the format; mechanical and electrical parameters of the format and their trade-offs; azimuth recording with Miller-squared channel code; picture-in shuttle; shuffling and concealment.

General Criteria

The general criteria for the D-2 format were set by its intended functions: a high-quality alternative to Type C VTRs; operation in the analog composite environment; capable of all current Type C play modes; multi-generation reproduction with transparent quality; and four channels of professional-quality digital audio.

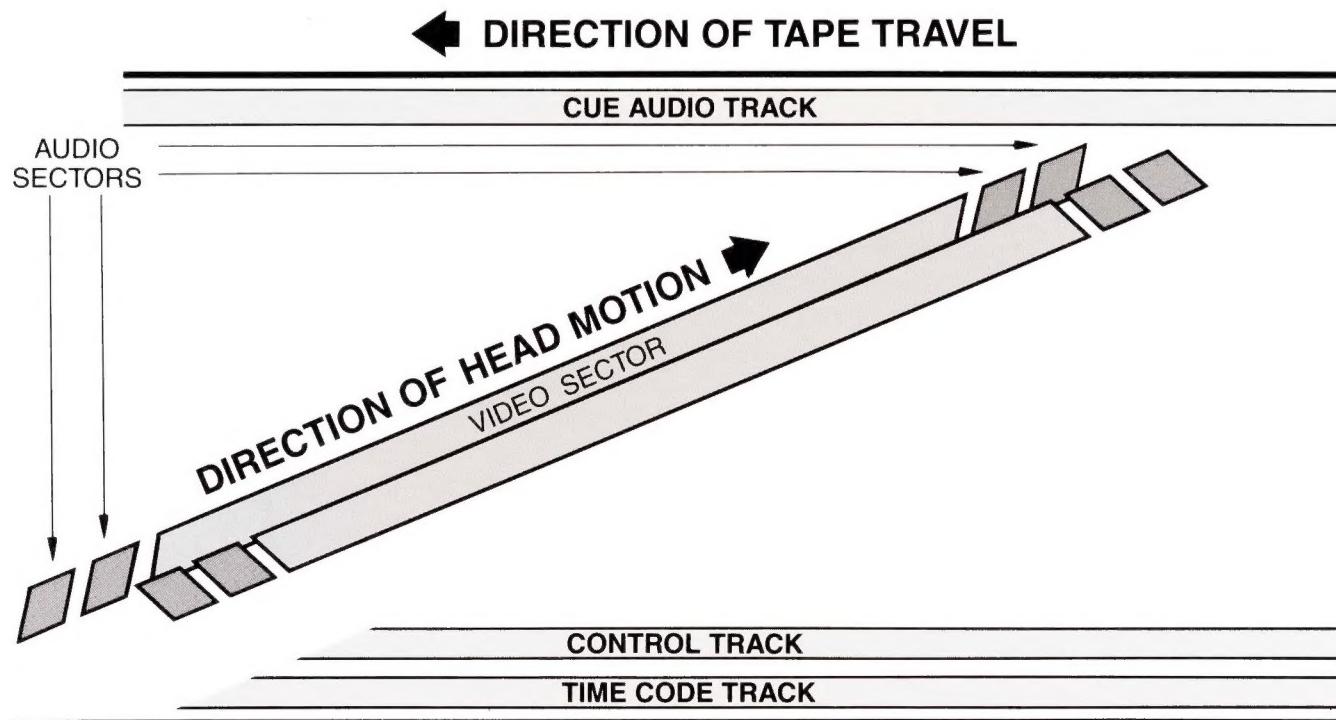
Economic factors were also considered. The D-2 format uses the standard "D" cassettes, but with play times increased approximately three times over the D-1 format. The D-2 format was conceived as a two-channel system having a simpler mechanical and electrical design than D-1, and a low cost of purchase, maintenance and operation.

Data Rates

For a digital VTR, the data rate is primarily determined by the digital video data rate. The recorded video data rate of a digital NTSC signal, sampled at 4Fsc with 8 bits of resolution, is about 94 megabits per second.

Four channels of digital audio, sampled at 48 kilohertz with a maximum resolution of 20 bits, and 100 percent redundant recording of audio for increased error protection, adds about 8 megabits per second.

D-2 Composite Digital Format



The combined video and audio data rate is about 102 megabits per second. Additional overhead for internal operations brings the total recorded data rate to about 127 megabits per second.

Wavelength and Track Pitch

There are primary physical constraints for all DVTRs. Wavelength and track pitch together determine the packing density on tape. The minimum acceptable wavelength is strongly constrained by spacing losses, which have an enormous effect on the achievable bit error rate. Currently, metal particle tape used in the D-2 format can be reliably recorded with shorter wavelengths than oxide-based tapes. Another constraint is track pitch, which is limited by mechanical tracking ability and the need for reliable interchange of tapes. Another constraint is the tape speed necessary to achieve a specified play time. There is an obvious trade-off between playing time and packing density.

There is also a relationship between track pitch, wavelength, and the other physical parameters of the format. All the variables, except for the number of tracks per field, are more or less fixed by external or mechanical considerations. Therefore, the number of tracks per field may be chosen to optimize the format. For a practical two-channel recorder, the number of tracks should be an even number equal to twice the number of segments per television field.

As an example, the trade-offs for six and eight tracks per field, corresponding to three and four segments per field respectively, are significant. Six tracks result in relatively wide tracks and short wavelengths, while eight tracks result in relatively narrow tracks and long wavelengths. Thus, the number of tracks per field is a fundamental decision in any digital VTR format, which affects the relative complexity of the mechanical and electrical aspects of the recorder.

In the D-2 format, there are three segments and six tracks per field. This results in a minimum wavelength on tape of 0.85 micrometers. Although somewhat less than the D-1 wavelength, this is very reasonable with metal particle tape. The D-2 track pitch is 39 micrometers. Although less than the D-1 track pitch, the track width is actually somewhat greater than in D-1, due to the lack of a guard band between the helical tracks.

Guard Band Eliminated

The D-2 format does not use a guard band between the helical tracks. Instead, azimuth recording is used, to reduce interference from neighboring tracks. The rejection of interference is most effective when long wavelengths on tape are not recorded. Accordingly, the channel code used is "Miller squared," which is DC-free, and has run lengths ranging between 1- and 3½-NRZ bit cells.

NRZ recording produces long wavelengths on tape that create fringing fields which extend beyond the track boundary, necessitating a guard band between tracks.

Since fringing fields from long wavelengths are not present with the DC-free Miller-squared channel code, the guard band is not necessary. Azimuth recording can be used to further reduce crosstalk between the tracks. Eliminating the guard band can improve the packing density by as much as 30 percent. The record and playback head gaps are wider than the track pitch. This allows the playback heads to drift off-track a considerable amount before the error rate increases excessively.

The off-track error rate versus distance for azimuth recording with Miller-squared channel is worthy of note. The heads can drift off track by as much as 20 μ m, with an error rate that is still correctable by the ECC system. This reduced sensitivity to tracking errors permits the use of a simpler and less costly mechanical design, and improves interchange performance. Tests have shown that

the ECC system continues to perform on interchange tapes up to about 25 μ m in each direction. This is greater than 50 percent of the total track pitch, which is 39 μ m.

Fewer Heads Required

In addition, the relatively narrow range of recorded wavelengths and frequencies allows Miller-squared code to directly overwrite a previous recording with no significant increase in error rate, thus eliminating a set of rotary erase heads or erase gaps in the record head. The absence of a guard band is necessary to realize the overwrite ability. The elimination of these erase heads or gaps results in a worthwhile mechanical and electrical simplification of the recorder.

The Ampex scanner configuration has an effective wrap angle of just under 180 degrees, so that only one pair of heads is on tape at any time. This is similar to the VHS format except that pairs are used instead of single heads. This design represents the least complexity, and is therefore the most reliable DVTR scanner. The scanner requires only four head pairs for record/play, compared to the sixteen individual heads used in D-1 format machines.

Error Detection/Correction

Error control strategy is based primarily on a two-dimensional Reed-Solomon error correcting code consisting of "inner" and "outer" codes. As in D-1, the inner ECC code is common to both audio and video sectors. Secondary error control depends on concealment of uncorrectable (but detectable) errors. In addition, each audio sector is recorded twice on tape, on different tracks and at opposite ends of the tracks, for increased protection against audio errors.

The Reed-Solomon code used in the D-2 format is a "superset" of that used in the D-1 format, providing significantly more powerful correction of both random and burst errors. The D-2 inner code blocks contain eight check bytes, and can correct up to three bytes in error and detect longer

errors with a high degree of confidence. The D-2 outer code blocks (both audio and video) contain four check bytes, and can correct up to four bytes in error using "erasure" flags from the inner decoder.

The burst error correction capability of the ECC code can correct error bursts up to about 2300 bytes long. This corresponds to a dropout of about 15 millimeters along the helical track or a longitudinal scratch about 1.7 millimeters wide. The audio code is capable of correcting bursts up to nearly 400 bytes long, without using the second copy of audio. Using the second copy of audio greatly enhances the effective correction ability.

AST Implementation

The footprint of the helical tracks containing the digitally recorded video and audio data are recorded in pairs, with each pair of tracks corresponding to one segment. The audio data is recorded twice, in sectors located at opposite ends of two different tracks, while the video data is recorded in the sector in the middle of each track. This has a distinct advantage during AST operation.

The start of the picture occurs at the start of the track. The AST head can jump and settle while the head is at the back of the scanner and not yet in contact with the tape. With the D-1 format, the audio is recorded in the center of the track. The start of the picture occurs after the audio bursts in the center of the track. If it were possible to design an AST head for the D-1 format machine, it would have to jump during the short audio burst and while the head is in contact with the tape.

Track Structure

The structure of the helical track is very similar to that of D-1. Each track is composed of one video and four audio sectors. Each sector contains a number of "sync blocks" which are identical in structure. As in D-1, each sector is preceded by a "preamble" and followed by a "postamble." This permits different types of sync detection algorithms to be

implemented. Adjacent sectors in a track are separated by "edit gaps" containing a fill pattern, to permit independent recording or editing of each sector.

The sync blocks, common to both video and audio sectors, each contain a synchronization pattern, an identification pattern and two inner code blocks. The same synchronization pattern is used as in D-1. The identification pattern is included in the first inner code block, for maximum protection of the ID. Every identification pattern is uniquely numbered over the entire helical track, as well as over the twenty-four tracks in the four-field video color frame sequence. No source code mapping or randomization is applied to the data recorded in each sync block because the Miller-squared channel code has a low data pattern sensitivity.

Data Shuffling

One of the challenges in the design of the D-2 format was how to handle the shuffling of the video data in a way that allows concealment of uncorrectable errors, yet also allows satisfactory picture in shuttle. The variation of the chroma phase of a sample from field to field introduces a problem which is not present in the D-1 component recorder.

During shuttle, the heads will be crossing the tracks and reading data from different fields. As the data is read, a buffer memory will be updated with samples from different fields in a more or less random manner, as the heads cross the tracks. If the data is well shuffled (for good concealment of errors), then each block of data on tape will contain samples which are widely spaced on the television screen and cannot be practically decoded into luminance and chrominance components. On the other hand, if the chroma phase of a sample in the buffer memory is uncertain or random, then the color of the reproduced picture in shuttle will be chaotic.

The solution adopted in D-2 is to vary the number of the first recorded line in a field over the four field color frame sequence, such that the first recorded line has the same chroma phase regardless of field. In this way, the buffer memory can be updated during shuttle mode without worrying about what field the data comes from, or recoding the chroma. Lines 10 through 263 are recorded for all fields, while lines 8, 9 and 264 are recorded for only some fields. These few lines occur in the vertical interval and do not contain necessary video information.

Conclusion

The D-2 format balances the electrical, mechanical and economic aspects of the recorder, offers superior multi-generation performance, robust and reliable operation, economy, compatibility with the current composite environment, and its capabilities have now been demonstrated in the Ampex VPR-300.

*For more information on the development of the D-2 composite digital format, see *Design Considerations for the D-2 NTSC Composite DVTR* by Richard Brush.